ADVANCED PRODUCTION & QUALITY MANAGEMENT

LESSON PLAN

Course Number: PQM 301

Module & Title: Lesson No. 1, New Paradigms

Length (total): 2 Hours

Terminal Learning Objective:

Given the lecture, discussions, and exercise the student will be able to define the impact of a changing quality paradigm on the manufacturing and QA community. This lesson provides students with the opportunity to discuss new paradigms that should be affecting the way they do business. The new paradigms targeted in this lesson include; new quality definitions, and IPPD paradigms. Students will discuss the impact of these changing paradigms as they relate to the Mfg/QA community.

Enabling Learning Objectives:

1. **Compare the old and the new quality paradigms.** The students will identify the new emerging paradigm for quality. They will then compare and contrast that paradigm with the old one. Basically we are going from inspecting quality to designing and building it in. Students will use this time to develop their own definitions for quality.

2. **Identify the impacts of the new IPPD paradigm on Mfg/QA.** The students will identify the new paradigm for systems engineering (IPPD). Discuss and contrast sequential engineering with IPPD concepts.

Learning Method: Lecture/Discussion/Exercise

Student Readings: Chase & Acquilano, Chapter 5, pages 186-196
DoD Deskbook, "Quality," Section 2.6.E

Background References: Quest for Quality, Roger Hale, The Tennant Company, Minneapolis, MN

Conduct of the Lesson:

This lesson is conducted primarily by discussion and some lecture as appropriate. The TLO is accomplished in two major parts - The Development of the New Quality Paradigm, The Development of the New Engineering Paradigm

The section on Developing New Quality Paradigms takes students through discussions of numerous definitions of quality. Some of these definitions reflect the old paradigm (acceptable quality levels) and some of the definitions will reflect the new paradigm (perfect 1st time quality). Students will develop their own definition of quality that will be used in the RFP exercise to drive contractor behavior to reduce cost while improving quality.

The second section takes students through an analysis of the changing paradigm within the engineering community. Classic engineering models have the engineers working in near vacuums to develop products that meet performance and test requirements. Once they meet those requirements the design is thrown over the wall to manufacturing that has to build to print. The problem is that the design is not producible. The new paradigm has design engineering working very closely with all the other functional areas, especially the technical areas. The goal is to create a design that meets performance requirements while optimizing the ease and economy of fabrication, assembly, test, maintenance, reliability, supportability, safety, affordability, et. al.

Defense Acquisition Deskbook, Section 2.6.E

Quality

Description

Quality products and services are fundamental to successful military operations, as well as to successful system development and production. The quality of products, or services is determined by the extent they meet (or exceed) requirements and satisfy the customer(s) at an affordable cost. The goal of an effective acquisition program is to acquire goods and services that meet or exceed DoD requirements, better, faster, and at less cost. The emphasis and practices to achieve quality have evolved dramatically in recent years. The major shift in defense acquisition is to emphasize development of quality products through design of the product and its associated processes. The key to success here is to prevent quality problems through sound processes, not to find them later and do rework.

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Mandatory References

Federal Acquisition Regulation
FAR Part 46, “Quality Assurance”

Defense Federal Acquisition Regulation Supplement
DFARS Part 246, "Quality Assurance"

Defense Logistics Acquisition Regulation
DLAR 46 Quality Assurance

DoD Directive 5000.1, Defense Acquisition, March 15, 1996
Para.D.2., "Acquiring Quality Products"

DoD 5000.2-R, "Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information System Acquisition Programs, March 15,1996
Part 4.3.2, "Quality"

AF Policy Directive 63-5; Quality Assurance; 7 September 1993

AF Instruction 63-501; Air Force Acquisition Quality Program; 31 May 1994

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Discretionary References

Army - AMC Pamphlet 70-27, Guidance for Integrated Product and Process Management
Vol II, Applications
  Section III. Integrated Product Team Life Cycle Responsibilities
    D. Engineering and Manufacturing Development, Phase II
      Worksheet IV, Phase II
        "Quality Assurance"
Vol III, Tools and Practices
  Section II IPPD Tools and Technologies,
    A.2. Modeling Tools and Techologies
      "Quality and costumer satisfaction..."

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Quality Management Systems

GENERAL GUIDANCE

Traditional quality management systems have typically focused on the identification and control of hardware that fails to meet specified requirements. Although preventing nonconforming material from reaching the hands of the customer is a critically important function, the traditional quality assurance approach suffers from a number of drawbacks. Foremost among these is that identification and control of defects have proven to be much more costly than preventing their occurrence in the first place. Secondly, inspection and test—even when performed on a 100% basis—often fail to identify all existing nonconformances. Lastly, the use of end item inspection as a principal means of determining product acceptability has frequently led to the perception that workers who perform such inspections and tests—rather than those who design, fabricate, assemble and maintain the product—are responsible for product quality. This shift of responsibility away from those who design, fabricate, assemble and maintain the product, deters effective focus on the product and process design elements instrumental in achieving quality. Unlike the traditional quality approach to obtaining quality products which focused on conformance, product quality is an attribute that is controlled by the engineering/design and business processes, as well as maturation of the associated manufacturing/production process.

This changed view of quality resulted in the following major policy changes which have dramatically changed the DoD perspective on quality:

—SECDEF Memorandum of June 29, 1994, Specifications and Standards - A New Way of Doing Business, encourages use of commercial practices and requires contractors be given flexibility to identify their own quality system requirements. Achievement of quality requires an effective quality management process be employed in conjunction with effective business and technical practices. Achievement of quality requires engineering and manufacturing practices that emphasize robust design, along with enterprise-wide continuous process improvement efforts. Benefits include first time or first pass quality, decreased cycle time, as well as reductions in rework, engineering changes, and inspections. Defense contractors should be required to have a quality system which adheres, at a minimum, to the twenty elements described in ANSI/ASQC-9000. Such a system relies on assessment of the contractor's quality management process, process controls, inspection, and test.

—SECDEF Memorandum, dated May 10, 1995, entitled Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition, provides the framework for achieving quality products through integrated product and process development. Quality products are best achieved through integrated development of the product and its associated manufacturing and support processes, which is an integral part of systems engineering.. Quality must be an integral part of the work of integrated product teams and implementation of IPPD.

—SECDEF Memorandum, dated December 6, 1995, subject Common Systems/ISO-9000/Expedited Block Changes, and USD(A&T) memorandum, dated December 8, 1995, subject Single Process Initiative, provide policy on the use of single processes in a contractor's facility. These memos were intended, in part, to expedite the shift from military quality standards to commercial (ISO/ANSI/ASQC) standards. The goal is to preclude requiring, in a single facility, multiple quality, business or technical processes designed to accomplish the same purposes. The implementation of the single process initiative has coincided with the formulation of local management councils (consisting of representatives of the buying activities, ACO, DCAA and contractor) at affected contractor facilities to assess process issues. Contractor proposed implementation will be reviewed based on submission of concept papers. The program manager should support contractor efforts to implement a single quality management system throughout their facilities. This policy represents a major DoD initiative allowing industry to be more efficient, improve quality and reduce the overall cost of acquiring products.

USD (A&T) Memorandum of February 14,1994 entitled: Use of Commercial Quality System Standards in the Department of Defense requires contractors be given flexibility to identify their own quality system requirements and encourages use of a single quality process in a contractor's facility. The referenced MIL-HDBK-9000, however, is no longer valid due to the new policy of SECDEF memorandum of June 29, 1994, Specifications & Standards - A New Way of Doing Business, which encourages use of commercial practices and requires contractors be given the flexibility to identify their own management systems.

Achievement of quality requires an effective quality management process in conjunction with effective business and technical practices. Achievement requires engineering and manufacturing practices that emphasize robust design along with enterprise-wide process maturity through continuous process improvement efforts. Benefits include first time pass quality, decreased cycle time, as well as reductions in rework, engineering changes, and inspections. These benefits translate into improved affordability and reduced production transition risk. A basic quality management system should be a requirement of the contract, and should adhere, at a minimum, to the twenty elements described in ANSI/ASQC-Q9000. A basic quality management system relies on assessment of the contractor's quality management process, process controls, inspection, and test and is primarily focused on controlling and detecting manufacturing defects.

Unlike the traditional quality approach to obtaining quality product which focused on conformance, product quality is now viewed as an attribute that is controlled by the engineering/design and business processes, as well as the maturation of the associated manufacturing/production process.

Achievement of quality must be the underlying objective in all program matters including source selection, contract administration and supplier management, risk management, engineering, manufacturing and testing processes, etc.. Quality is the product of effective implementation of these processes. While final inspection and acceptance, and the need to determine the conformance of the product through end item inspection will continue as long as tax payers dollars are being spent, the focus on how to achieve quality has expanded to one of ensuring the appropriate use of best engineering, manufacturing and management practices.

To achieve quality products and services one must focus on the following:

(1) Quality of Design. The effectiveness of the design process in capturing the operational, manufacturing and quality requirements and translating them into robust design requirements that can be manufactured (or coded) and supported in a consistent manner.

(2) Conformance to Requirements. The effectiveness of the design and manufacturing functions in meeting the product requirements and associated tolerances, process control limits, and target yields for a given product group.

(3) Fitness for Use. The effectiveness of the design, manufacturing, and support processes in delivering a system that meets the operational requirements under all required operational conditions.

(4) Cost. The cost of the product and how the design, manufacturing, and management processes affect unit and life cycle costs

The following guidelines for establishing and maintaining an effective quality management program are discussed below:

1. Application and use of commercial quality management standards
2. Encouraging use of a single quality process in a contractor's facility
3. Recognizing and encouraging the appropriate use of practices and tools that lead to acquiring a quality product
4. Establishing and implementing efficient and effective oversight

APPLICATION AND USE OF COMMERCIAL QUALITY STANDARDS

Policy and guidance on the application of quality standards is provided in the FAR Part 46; DFARS Part 246; and SECDEF memorandum of 29 June 94, entitled "Specifications and Standards-A New Way of Doing Business"; and USD(A&T) memorandum of December 8, 1995, titled "Single Process Initiative"

DoD organizations are authorized to use ANSI/ASQC Q-9000, and/or the ISO-9000 series standards in all new contracts, and follow-on work for existing programs, provided contractors are given the flexibility to respond with their own equivalent quality systems. The ANSI/ASQC documents covered under ANSI/ASQC Q-9000 represent different levels of quality requirements outlined as follows:

ANSI/ASQC-Q9001 "Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing"

ANSI/ASQC-Q9002 "Quality Systems - Model for Quality Assurance in Production and Installation"

ANSI/ASQC-Q9003 "Quality Systems - Model for Quality Assurance in Final Inspection and Test"

ANSI/ASQC Q-9001, Q-9002 and Q-9003 are the U.S. equivalents and equal to the international quality standards ISO 9001, ISO 9002, and ISO 9003, respectively. The guidance herein applies equally to both the ANSI/ASQC Q-9000 series and the ISO-9000 series documents. Additional guidance on the non-government standards, such as ISO 10005, "Quality management - Guidelines for quality plans," is available through ISO 9000 and 10000 series documents listed the DoD Index of Specifications and Standards.

The elements of ANSI/Q-Q9000 represent a framework for a basic quality system, however, they should not be viewed as the only commercial quality specifications available, nor the most effective basic quality system requirements. Many other industry quality standards (i.e. the auto industries QS-9000) exist and are potentially more effective than the ISO or ANSI 9000 quality standards. It is therefore in the DoD policy to cite the DoD requirement with the words “or equivalent” to allow offerors the flexibility to propose their own equivalent quality system. Quality systems that satisfy DoD acquisition needs should be recognized whether they are modeled on military, commercial, national, or international standards.

The ANSI-9000 standards have a number of limitations in that they address the elements of a contractor’s quality system, but do not address the application of such a system to the products or processes as related to a particular contract. This limitation can be overcome by use of the following statement of objective (SOO) language.

In implementing this guidance in competitive requests for proposals (RFPs) buying activities may consider the following suggested language for performance based statement of work (SOW) the statement of objectives (SOO), Section L, and Section M. (While the sample language that follows is structured for a development phase RFP, it is adaptable for production phase RFPs.)

<u>Suggested SOW/SOO language for a quality system requirement</u>. “ The contractor shall implement a quality system that satisfies the program objectives and is modeled on ANSI/ASQC Q9001, or an equivalent quality system.”

<u>Suggested Section L language</u>. “Offerors shall propose a quality system that satisfies program objectives and is modeled on ANSI/ASQC-9001, or an equivalent quality system.” Offerors shall:

a) Describe the proposed quality system, explaining how it will be applied to reduce program risk, and specifically addressing (as a minimum) the quality system’s role in design and development (with particular emphasis on addressing key product characteristics), manufacturing planning, and key program events.

b) Provide a relational matrix comparing, in detail, the proposed quality system with each of the elements of ANSI/ASQC-Q9001”

<u>Suggested Section M language</u> “The offeror’s quality approach will be evaluated based on its effective:

a) application to all appropriate aspects of the program
b) coordination with other functions
c) integration into overall program planning; and
d) contribution to reduction of program risk.”

The offeror’s ability to satisfy the quality management system objectives should be assessed in source selection and continuously monitored after contract award. The elements of ANSI/ASQC-9000 formulate the baseline for review and approval of a contractors quality management process. In reviewing contractor quality management systems, particular emphasis should be given to management responsibility, supplier control, corrective and preventive action, and internal audit.

USE OF A SINGLE QUALITY PROCESS IN A CONTRACTOR’S FACILITY

DoD Policy on the use of single processes in a contractor’s facility is provided in SECDEF memo, dated Dec. 6, 1995, subject Common Systems/ISO-9000/Expedited Block Changes, and USD(A&T) memo, dated Dec. 8, 1995, subject Single Process Initiative. These memos were intended, in part, to expedite the shift from military quality standards to commercial (ISO/ANSI/ASQC) standards. The goal is to preclude requiring, in a single facility, multiple quality, business or technical processes designed to accomplish the same purposes. The implementation of the single process initiative has coincided with the formulation of local management councils (consisting of representatives of the buying activity, ACO, DCAA and contractor) at affected contractor facilities to assess process issues. Contractor proposed implementation will be initiated based on submission of concept papers. The PM should support contractors' efforts to implement a single quality management system throughout their facilities.

The above policy represents a major DoD initiative allowing industry to be more efficient, improve quality and reduce overall cost of acquiring products.

RECOGNIZING AND ENCOURAGING THE APPROPRIATE USE OF ENGINEERING AND MANUFACTURING PRACTICES

As previously stated, the prevention of defects, rather than the detection of defects, is the goal of the Department. Advanced quality practices is a term identified by some in industry to mean the appropriate, timely application of engineering, manufacturing, and management practices that emphasize the prevention of defects, rather than detection of defects. Advanced quality practices need to be defined within an organizational context, not as a stand alone list. What may be appropriate for a design, or low rate production enterprise, may not be for a commodity manufacturer, and vice versa. Some of the more commonly used practices in industry include:

1. Identification and control of key characteristics
2. Design to manufacturing process capability
3. Design for manufacturing and assembly (DFMA)
4. Robust design
5. Geometric Dimensioning and Tolerancing
6. Process Variability reduction, of stable, capable manufacturing processes as the basis for product acceptance
7. Control of variation in the measurement system
8. Failure reporting analysis and corrective action system
9. Continuous improvement
10. Other tools such as use of modeling and simulation, CAD/CAE/CAM, and use of maturity models, etc.

While the requirement for a basic quality system is incorporated as a requirement into DoD contracts, the contractors ability to effectively implement the appropriate and effective application of the above type of development and manufacturing practices and tools to meet product requirements is fundamental to achieving quality products; i.e. products that meet the user requirements at an affordable cost.

ESTABLISHING AND IMPLEMENTING EFFECTIVE AND EFFICIENT CONTRACTOR SURVEILLANCE

The cognizant CAS activity verifies that contractors have processes and a quality system that meet contract quality requirements and produce quality products. In coordination with effected Program Manager Offices and buying commands, the CAS activity:

- Identifies critical processes
- Develops and maintains a written risk based surveillance plan
- Performs necessary surveillance
- Performs data analyses and adjusts surveillance accordingly

By working in coordination with each other, the Program Manager Offices/buying commands and the CAS activity can minimize the disruptive impact of DoD surveillance efforts on contractor operations, and reduce DoD's costs of surveillance.

The CAS activity derives confidence from credible contractor data when feasible, but performs sufficient product audits to maintain confidence in that contractor data. DCMC performs independent product audits to verify product conformance with contract technical and quality requirements. When contract non-compliances are observed, the CAS activity requests, evaluates, and verifies contractor corrective actions. The CAS activity also encourages contractors to self-audit and pursue process maturity and effectiveness, waste minimization and continuous improvement.Deficiency Reporting. DoD Components should establish a product deficiency reporting and correction system to track and record the status of the products ability to meet user requirements with feedback to the system developer. The contractor should implement a system that identifies the root cause of in-plant and field defects and promotes design/process changes necessary to prevent their recurrence.

The responsibility and leadership for creating an environment for effective quality design and manufacturing belongs to the highest levels of management. Program managers must convey the leadership and commitment by their own actions in communicating goals, making process effectiveness a key program management issue, and the commitment of resources.

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ADVANCED PRODUCTION & QUALITY MANAGEMENT

LESSON PLAN

Course Number: PQM 301

Module & Title: Lesson No. 2, Systems Acquisition Overview

Length (total): 1.5 Hours

Terminal Learning Objective:

Show the current systems acquisition life cycle phases as well as major activities to be accomplished in each phase. Relate the impact of the on-going acquisition reform initiatives to the current life cycle. *This lesson introduces the current acquisition reform initiatives, the requirements generation or pre-milestone 0 activities, and the current DoD 5000 series directive and regulation guidance. These systems acquisition life cycle phases will be referenced throughout the course to establish the time frame of topics covered.*

Enabling Learning Objectives:

1. Relate the current acquisition process initiatives (e.g. Integrated Product / Process Development/ Integrated Product Teams, performance-based specifications, opens systems approach, Cost as an Independent Variable, etc.). *Current acquisition reform initiatives will be summarized and addressed as the "new way of doing business" as set forth by USD(A&T) and USD(Acquisition Reform). Open Systems definitions, terms, and concepts will be introduced and addressed throughout the course, the use of performance-based specifications and standards, reliance on commercial items and standards, and the current DoD Directive 5000.1 and DoD Regulation 5000.2 policy guidance are discussed.*

2. Differentiate the requirements generation system and the program, planning, and budgeting system to the acquisition management system. *These three decision-making systems are used in the DoD pre-milestone 0 and program execution acquisition stages. The breadth of each of these systems and their interrelationships are discussed. Application knowledge of these decision-making systems are important to the SPRDE functional area.*

3. Distinguish between the different life cycle activities and their interrelationships. *The life cycle activities (from ACQ 201) will be discussed and the changes brought about by the current 5000 series documents that impact the life cycle for the development, production, and support of a system.*

Learning Method: Expository Discussion

Student Readings: None

Instructor Readings: "Acquisition of Defense Systems," Przemieniecki,
Chap. 2,3,7, Chap 10, pp. 177-203.
Chap. 13, pp. 85,86, and pp. 243-257.

Background References: DoDD 5000.1 (Mar 15, 1996)
DoD 5000.2-Regulation (Mar 15, 96)
Process Action Team on Military Specifications and Standards Report recommendations (Report #AD-A 278 102)
EIA IS-632/IEEE 1220
Federal Acquisition Streamlining Act (FASA)
"Specifications & Standards - New Way of Doing

Business" memo of Dr. Perry's dtd 29 Jun 94
MOP-77
Cost as an Independent Variable (CAIV) memo dtd 4 Dec 95

Conduct of the Lesson:

This lesson is conducted by expository discussion where appropriate. The TLO is accomplished by three major parts - Requirements Generation, Acquisition Life Cycle, and Acquisition Reform-"New Way of Doing Business".

The Requirements Generation portion of this lesson will focus on the pre-milestone activities leading up to the Mission Need Statement and will be a review of some of the material presented in the ACQ 201. Emphasis is placed on how this process can lead to the development of materiel solutions to meet user requirements. The interrelationships of the three decision-making support systems - Requirements Generation; Planning, Programming, & Budgeting; and Acquisition Management will be emphasized (ELO 3).

The Acquisition Life Cycle portion of this lesson will present pertinent changes being introduced by the current DoDD 5000.1 and DoD 5000.2-R (ELO 2). The acquisition "chain of command" and acquisition categories will also be discussed.

Acquisition Reform will be addressed from the viewpoint of a "New Way of Doing Business". Topics will include open-systems architecture, performance-based specifications, IPPD, commercial standards and specifications, commercial items and non-developmental items emphasis, and other new mandates addressed in the DoDD 5000.1 and DoD 50002-R (ELO 1).

LESSON ASSIGNMENT SHEET

Advanced Production &
Quality Management Course (APQMC)

Course Number: **PQM 301**

Module & Title: **Lesson No. 3, Risk Management**

Length (total): **2 Hours**

Terminal Learning Objective:

Given lecture, discussion, and an illustrated acquisition program case exercise the student should be able to resolve risk issues with mitigation measures in an Integrated Product and Process Development (IPPD) / Integrated Product Team (IPT) environment.

Enabling Learning Outcomes: The student will be able to:

Define the background and rational for updated risk management policy in DoD.

Define the basic categories and examples of risk for acquisition programs.

Describe recent lessons learned from past risk management programs.

Describe Measures of Effectiveness for a Risk Management Process.

Evaluate the application of a hypothetical Risk Management Process and make recommendations to improve the process to mitigate a program's risk within an Integrated Product and Process Development (IPPD) / Integrated Project Team (IPT) environment.

Assignments:

Review: Attached Teaching Note, "Program Risk Management", dated October 5, 1996
Read: Case study for class exercise for evaluation of an applied risk management process.

Expected Student Preparation Time: 90 minutes

Advanced Production &
Quality Management Course (APQMC)

Teaching Note

Program Risk Management

Bill Bahnmaier and Paul McMahon
October 5, 1996

Introduction

Risk management is concerned with the identification of uncertainties that threaten cost, schedule, and performance objectives, and the development and implementation of actions to best deal with those uncertainties within established limits. Its primary focus is:

- To identify and manage risk so that program objectives can best be achieved, and

- To support development of an acquisition strategy to meet the user's needs while balancing cost, schedule, performance, and risk.

With a few praiseworthy exceptions, we in defense acquisition have not been particularly effective in achieving these objectives. We are entering an era in which we must do better and can no longer rely on "The Threat" to compensate for unrealistic cost, schedule, and performance objectives that do not adequately recognize program risks. "Cost as an Independent Variable" (CAIV) - in which DoD no longer pursues attainment of performance objectives at "ANY COST" - is now a cornerstone of the acquisition approach under acquisition reform. Programs that experience significant cost growth or schedule slips are more likely to be canceled than bailed out. Successful programs will be those that begin with recognition of major risks are managed to bring systems in on time, within budget, and to performance objectives.

Terms and Definitions

Risk. In general, risk can be defined as the possibility of loss or injury. It has two components: a likelihood of occurrence (probability), and an undesirable consequence. Unless we understand both of these components, we will have difficulty in dealing with it effectively.

Acquisition Risk. Every program is subject to uncertainties that may result in failure to achieve cost, schedule, or performance objectives. Exposure to these adverse possibilities constitutes acquisition risk. The Air Force Risk Management Guide defines Acquisition Risk as:
"..... a measure of the inability to achieve program objectives within defined cost and schedule constraints. This inability is the result of one or more undesirable events that occur during the program life cycle, for which there are not sufficient resources and time programmed to overcome."

Areas/Sources of Risk. Areas of acquisition risk may appear endless to the program manager. They fall generally within external and internal to the program office. Within those general categories, the following are the areas, or sources, of risk.

- *Threat and Requirement.* Changes in the threat or a poorly defined requirement can result in redefinition of program performance objectives.
- *Funding.* Significant changes in funding levels can force stretch-outs, performance reductions, or worse case, cancellation. The program's acquisition strategy is developed based on an assumption of a certain level of funding.

- *Contractor.* Programs are subject to potential inability to meet cost, schedule and performance objectives when anything that affects the ability of the contractor to function occurs, such as labor strikes or financial difficulties.

- *Politics*. Program managers may receive "help" from external sources (service headquarters, DoD, Congress, etc.) that direct the program to assume certain cost and/or schedule constraints whose results will significantly increase the risk of meeting program objectives. Though the program manager may not be able to deflect these fact-of-life directions, he or she must still understand exactly how and where and to what extent the program risks increase.

- *Technology*. Technology risks result from the use of immature technologies to achieve previously unattained performance levels. The more the program incorporates immature technology, the greater the uncertainty to cost, schedule, or performance projections.

- *Design and Engineering.* Design and engineering risks are associated with the ability to translate technological capabilities into reliable hardware and software configurations.

- *Manufacturing.* Manufacturing risks reflect the ability of the government[1], and/or the contractor, to build the designed system to performance and quality standards.

- *Support.* Support risks are those associated with achieving reliability, availability, and maintainability objectives.

- *Cost and Schedule.* The accuracy of the cost and schedule estimating process, and their supporting assumptions, impact the level of cost and schedule risks incurred. Risk can also be infused into the schedule because of bottlenecking events, or high level of concurrence, both of which tend to create multiple critical paths in the work effort.

Significant risk will normally impact Cost, Schedule, and Performance. The risk areas are usually interrelated. As an example, a program with a large technology gap will often have high design, engineering, and/or manufacturing risks. Conversely, manufacturing and support risks may be reduced by increasing emphasis on integrated design, manufacturing and support processes through concurrent engineering. With heavy emphasis in acquisition reform on Cost as an Independent Variable (CAIV), cost (and cost risk) will be more of a constraint on performance and its associated technical risk.

Risk Management and Program Management

The basic responsibility of the program manager is to achieve his or her program performance objectives within cost and schedule limits. It would be nice if all we had to do to accomplish this was to carefully execute the acquisition strategy. It isn't that easy. Acquisition is an inherently uncertain and risky business. Managing risk is a basic responsibility of every program manager. Every program has risk. Some PMs believe program management is risk management.

Since program risk is directly related to the uncertainty in the program's ability to meet cost, schedule, and performance objectives, it can only be measured relative to these objectives, and within the context of the program's acquisition strategy. Change the strategy and you change the risk. Unrealistic program strategies can infuse as much if not more risk into a program as using advanced technologies. Development of a realistic plan that recognizes and accounts for program risk is, by far, the most effective risk management technique and it must be an integral and continuing part of the general program planning and control processes.

For a manager to best manage risk, he or she must understand:

- What adverse events may occur.

- The likelihood (probability) of the event occurring.

- The severity or impact of the cost, schedule, and performance effects.[2]

Given this level of understanding, the manager is in a position to seek ways to do one or more of the following:

- Make it less likely that the risk will occur.

- Deal with the cost, schedule, and performance effects of the risk event in ways that minimize damage to the program.

- Decide to accept the risk as reasonable given the cost, schedule, and performance advantages of the acquisition strategy and the program's requirements.

As you examine the risk management process, put yourself in the position of the program manager. Think about the information you need to effectively and efficiently allocate scarce program time and resources. Ensure you understand how the process will provide that information, and how you would use the process to make decisions relative to cost, schedule, performance, and risk trade-offs.

Government and Contractor Roles in Program Risk Management

Prior to program initiation and contractor selection, the Government's initial risk management role is to define the requirement, choose the best concept to satisfy that requirement, and define the basic acquisition strategy to be used to implement the concept. In doing this, the Government is establishing the fundamental risks that will challenge that program. It may also be laying out the basic risk management approach the program will take[3], as well as how the risk will be allocated between itself and the contractor.

To the maximum degree practical, industry input should be invited during the initial identification of risks and development of the initial risk management process and plan. The draft Request for Proposal (RFP), which should be sent for industry comment prior to milestone I, is one of the best tools available to help in this effort. Since the contractors are the ones best qualified to identify and evaluate the risks associated with a program, they should be intimately involved in risk management once they are selected. If they assist with development of the risk management strategy, not only should the risk abatement plans be more feasible, the contractor should also be better motivated to manage them. The government needs to coordinate its efforts enough with the contractor to ensure the plan is not too optimistic nor is developed to meet contractor generated political goals and timelines. As the program matures, the contractor should progressively move toward leadership in the risk management program. However, just as the government can never totally transfer risk, it should never totally transfer risk management responsibility to the contractor. The government program manager must retain the ability to continuously monitor the risk condition of the program.

Risk Management Process

Overview. The remainder of this teaching note will be based on a logic model of the risk management process that breaks this process into logical steps. Its purpose is to help you evaluate and organize risk management in your program office. Though the model is presented in a linear fashion, it is recognized that this is a simplification. In reality, some of the process steps may occur simultaneously, and the process flow may even reverse itself at times as new information is received that changes perceptions. Nonetheless, you can apply this model to any risk management situation.

At the top level, this risk management model is based on a simple and common sense sequence of risk management actions (figure 1 below). First, we organize and prepare the program management office for the effort (Risk Management Planning/Preparation). Second, we assess the risk events within the context of the acquisition strategy (Risk Assessment). Third, we identify and implement specific responses to these risk events and choose those that are best for mitigating their impact on the program (Risk Handling). Finally, we monitor and report the specific responses as a part of the plan in order to determine if our risk handling responses are on track (Risk Monitoring/Reporting). These risk management actions will repeat themselves as the program proceeds, and as we continually refine and mature our acquisition strategy and program execution.

The risk management model breaks the basic management actions into a more detailed series of process steps. For each action, we will describe the process and the products from the viewpoint of the customers[4]. The flow of these steps and the resulting products is shown in the risk management process flow chart at **attachment (1)** to this teaching note. You may want to refer to that chart as we explore each step.

The customers of the risk management process are both internal and external to the program office. Internally, the process should support the information and decision making needs of the program manager and the key functional managers in both the government and contractor program offices. Externally, it should support the needs of the key decision makers (e.g., PEO and MDA) and their staffs, and the needs of the review agencies that may be looking at the program. The key to this process model is an explicit identification of risk management products (such as risk and handling option lists and the risk management plan). For each customer, we should answer the following questions:

- What risk management products does the customer need in order to meet their management responsibilities?

How will he or she use those products?

How should the product be tailored in order to best support the customer's needs?

- How should the process be tailored to produce the product needed by the customer?

Now we are ready to discuss the details of the risk management model.

Figure 2 - Risk Management Planning/Preparation

Initial planning/preparation by the program manager should focus on the assessment phases of risk management. Integration of assessment efforts with the acquisition strategy is essential, and should be noted as a risk management project objective. In order to be effective, the preparation team must:

- Define the program's situation in terms of the resources, time, and expertise available to support risk management, and the types of risk with which the assessment team will be working.

- Identify, evaluate, and choose those risk management tools and techniques that are feasible and which best support program needs.

- Organize and train to ensure consistent assessments of program risks in a format supporting program management. This training is more important than most people realize. Unless everyone on the IPTs conducting risk assessments uses the same definitions, and comparable criteria for identifying and quantifying risks, it will not be possible to compare, rank, and consolidate them effectively.

- Establish schedule, budget, and appropriate controls to bring the risk management products in when they are needed.

- Establish a Management Information System (MIS) to document the analyses and decisions as they occur and to disseminate them as needed so they can be integrated.

Figure 3 - Risk Assessment

Risk assessments are accomplished by a Integrated product/process teams with the expertise to evaluate risk within their product/process areas. Their objective is to identify and evaluate events or circumstances that may have an adverse cost, schedule, or performance effect on the program. Generally, this is done by breaking the program into elements small enough to analyze effectively[5], and then:

- Identifying and describing events or circumstances having adverse effects (Risk Event Identification).

- Analyzing them to determine their likelihood of occurrence and their consequence on cost, schedule, and performance effects (Risk Analysis).

- Ranking and integrating the events to produce an assessment for each element. The elements are cumulated/“rolled-up” to higher levels until ultimately a program level assessment is achieved (Risk Integration).

Let’s look at these steps in the Risk Assessment Phase in greater detail below:

- Risk Event Identification

The objective here is to identify possible events and circumstances that will have an adverse impact on cost, schedule, and/or performance. We are not, at this point, seeking to quantify the degree of risk[6]. In order to do this, we need to identify a management structure to describe the program and which will:

- Break the program into elements small enough for evaluation.

- Support integration of risk assessments from lower levels to higher levels up to and including the program level.

- Allow collection, processing, and dissemination of risk related data in a form that best supports program management. Data collection is one of the more challenging elements to the risk management process.

A common practice and method for this organization is the program Work Breakdown Structure[7]. The WBS is a recognized planning, organizing, and controlling framework that completely describes the program, provides an accounting structure, and helps us guard against double-counting, that is, overstating risk by counting the same risk against more than one program element or activity. Importantly, the WBS is already required for most programs as a cost, schedule, and performance organizing and accounting vehicle. Using the WBS encourages integration of risk management into the overall management structure of the program[8].

Each element of the structure is analyzed to identify potential problems (risk events). Expert judgment is one of the most common tools used in this type of analysis. There are numerous other techniques and tools, including, brainstorming, Delphi, and nominal group technique, that can be used to augment and support expert judgment to stimulate and organize output. Computer and physical modeling, prototyping, developmental testing and science and technology projects are also used to identify potential risks and areas of uncertainty. Later in the program, cost and schedule variance analysis, and Technical Performance Measurement results can help to identify developing unknowns risk areas during program execution. At this point, the risk management process evolves into a program control process.

Consideration should be given to the maturity of the chosen technologies (including manufacturing technologies), the uncertainties associated with all input requirements (raw materials, preceding events, etc.), cost and schedule assumptions (labor rates, contract costs, inflation, etc.), and the number and complexity of interfaces. The analysis should consider the risk events identified for each element over the entire life of the program, within the sources of risk described earlier in this teaching note. A complete risk evaluation will consider all risk sources for all program elements over all program events. Figure 4 illustrates this concept that risk can be located at any level of the program and rolls up in a macro sense to Risk Areas at higher levels of the WBS. The risk evaluation system should include specific assignment of primary and supporting responsibilities for risk management, goals for risk reduction, and identification of the indicators to show that risk is under control. At the program office level, there should be a top level risk management organization. A common solution to this is to form a risk management integration team chaired by the deputy program manager, with representation from the major program IPTs, the contractor, and any others organizations affecting or who are affected by of the key program risk events. This group will focus on the top events, with lower level events being assigned to IPTs consistent with program WBS organization.

The identification of the risk events should be in such a form that the customers can understand:

- The circumstances causing them to occur,
- How to recognize them, and
- How they will affect cost, schedule, and performance.

- Risk Analysis

The objectives of risk analysis are to quantify impact of the risk event's occurrence, to estimate the likelihood (probability) of the event, and to identify relationships between risks. Program management planners, controllers and decision makers require this information in order to decide if they will accept the risk, or if they will try to reduce the risk by trading off cost, schedule, and/or performance.

The impact, or consequences, of each risk event must be described in terms of the cost, schedule, and performance effects on the program. Values used in these descriptions may cover a range (e.g., if this risk event occurs, cost will increase to a value within the range $xxx to $yyy, depending on ...), or they may be covered by a qualitative descriptor such as "critical, serious, moderate, minor, or negligible" (with appropriate cost and schedule definitions). Consistent process and format must be used so that risk events can be compared across elements and their consequences consolidated and rolled-up from lower levels to higher levels. Techniques to help quantify consequences include expert judgment, critical path analysis, computer modeling, and Monte Carlo analysis.

Understanding the probability of a risk event occurring is also important to the decision making process. If it is not possible to provide specific probability values for the event subjective probabilities may be assigned or qualitative descriptors, such as "high", "moderate", and "low" may be used to represent a range of probabilities. However, the values associated with these qualitative descriptors must be defined to ensure consistency of evaluation and accurate communication (e.g., low probability of occurrence will mean a less than 10% chance, moderate probability of occurrence will mean between 10% and 30% chance, etc.). Techniques for establishing a range of probabilities include modeling and simulation, expert judgment and comparison with previous efforts. Trying to establish a probability range in which you have a measure of confidence can be one of the most difficult parts of this process. The effort, however, that is expended to understand the probabilities improves the risk management team's knowledge and comprehension of the risks in a program. It is up to the program office to define the ranges of probabilities used in risk descriptors. These definitions must be presented whenever risk is discussed so that those outside of the program office understand their meaning.

There should be some estimate of the confidence that the analyst has in each risk quantification. This may be expressed using confidence intervals, or by defining percentage ranges for high, medium, and low accuracy (for example, high accuracy might mean that the analysts feels "confident" that the actual value is within + or - 10% of the estimate).

Although a single qualitative term may be used to represent the combined effect of the probability and consequences of a risk event (see following section on "Risk Integration"), their separate values must be retained. Without these values, decision makers have a difficult time conceptualizing and responding to these events as actual possibilities. Moreover, a single value that combines probability and consequence may produce a ranking of risk which may not be consistent to what would be obtained if the values were identified separately[9]. Dependencies should be identified to the maximum degree possible.

- **Risk Integration**

The objectives of this process step are to integrate, or “roll up”, risk events from lower level elements to higher levels, and to rank them in order of their potential to damage the program. Integration allows us to focus on the major program elements that contain the most risk, and to recognize the effect of cumulating the risks[10]. Actions by the team itself in the integrating effort can infuse risk into the program and they should be carefully considered at this point if they were not considered as a separate program element.

Risk ranking is required to best allocate scarce program assets. Because of the potential size and complexity of this process, the initial objective is to decide which risk events will consume resources and receive detailed handling option analysis[11]. Once the risks have been reduced to the most practical extent, risk ranking can be used to focus top management attention and mitigation cost on those risk events that have the greatest potential for harm.

Program damage is a function of the probability and the severity of the consequences. Both must be considered in the ranking process. Methods for combining these parameters include those which combine the probability measure and consequence measure (e.g., expected value, product of risk values[12], etc.) and those using a matrix to group risks in bands. This matrix (figure 5) is an example of one which might be used to rank principle program risks. In this example, taken from the Air Force Material Command Risk Management Guide, the risk element is described in the matrix cell, with the row identifying the probability of experiencing an adverse cost or schedule outcome relative to that element, and the column identifying the severity of the consequences (the number of rows and columns, and the values for ranges should be tailored to each program’s needs). High risks would be those in the upper right portion of the matrix and low risks would be those in the lower left corner lower left corner.

Whatever method is used, the risk identity, stated in terms of the risk event and the probability and severity of the consequence, must not be lost. These risk components are necessary to ensure that the risk rankings make sense, so that risk handling options may be developed and evaluated.

Risk events evaluated at lower level elements should be integrated to produce risk assessments for higher level elements. An integrated assessment should show a risk at least as high as the highest risk of any event included in the lower level element, and must recognize the cumulative effect of all the risk events. Caution should be exercised when using quantitative models especially in the roll up process.

The percentage of the risk events that are subjected to a detailed risk handling option analysis depends upon the number of risk events and the resources available to the program office. Those risk events that do not make the cut should still be assigned to the appropriate individual or IPT for continued management.

Figure 6 - Risk Handling

Risk handling begin with an alternatives analysis for each risk event. See Figure 6. Once a risk event has been identified for handling, the program manager reduces the risk by lessening either the probability or the consequence, or accepts the risk, given the cost, schedule, and performance objectives in the acquisition strategy. The basic objectives of risk handling option assessment are to identify the range of alternative responses to a risk event (Risk Handling Option Identification), to evaluate the alternatives relative to their costs and benefits (Risk Handling Option Analysis), and to choose those which would result in the best balance between cost, schedule, performance, and risk for the program (Risk and Risk Handling Option Integration). Let’s look at each of these process steps.

- **Risk Handling Option Identification**

The objective of this process step is to identify the potential risk handling options for dealing with the risk event under consideration. It is important to make an effort to identify a range of handling options for each event. This identification effort forces the manger to a more objective consideration of the costs and strategy alternatives available. There are five ways of handling risks. Each category for risk handling options should be considered.

1. *Risk Control.* Risk control options establish fall-back positions to minimize the effects of a risk event should it occur, as well as a control system that allows the manager to institute the fall-back option in time. As an example, a parallel development effort might allow the program to attain performance objectives if a primary effort fails. A Technical Performance Measurement system that tracks key risk indicators could be instituted to give the program manager adequate time to react if a risk event occurs. There are usually some cost or schedule trade-offs involved in establishing a risk control handling option.

2. *Risk Assumption.* Accept the risk without reducing either the probability or the severity of the consequence. This approach usually calls for a cost, schedule, or performance “trade space” that can be used if the risk event occurs. It may include, however, acceptance of the possibility of program failure.

3. *Research and Analysis*. Since risk is a function of probability and consequence, additional research and analysis (R&A) provides an opportunity to reduce the uncertainty associated with each identified risk event. R&A also identifies unknown risk events previously undiscovered. Developmental test and evaluation is a good example where more is learned about probability and consequences of failure in system designs. As we learn more about the risk events from developmental testing, we can then update our risk priorities and migrate to one of the other risk handling options such as control (including fixing the cause of the risk event), avoidance, assumption and transfer. R&A is the precursor to the actual mitigation of risk and provides the logic and basis for the Program Definition and Risk Reduction (PDRR) phase of the life cycle.

4. *Risk Avoidance*. Remove the risk by trading off cost, schedule, or performance. Examples include performance objective reductions, using more expensive material, or increasing the time allotted for an action. Risk avoidance options make it improbable that the risk event will occur.

5. *Risk Transfer.* Transfer the risk to some other element or organization usually with a cost, schedule, or performance trade-off. Examples include fixed price contracts and warranties, that transfer cost risk to the contractor (but not schedule or performance risk[13]) in exchange for additional cost to the program, or a re-allocation of performance requirements from one program hardware or software element to another, possibly with a reduction in risk and an increase in cost.

- Risk Handling Option Analysis

The objective of this analysis is to identify those risk handling options that are feasible and that reduce risks to acceptable levels with the best cost/benefit ratio. Quantification of costs must consider all of the overhead associated with the risk handling option, including additional personnel, schedule considerations, ranges and facilities, and data collection, processing and reporting.

Benefits of each risk handling option are quantified by modeling the application of an option to a risk event, and then applying the same techniques we originally used to quantify probabilities and consequences of that event to obtain a new result. It is important to apply the same consistency to obtain valid data for comparison.

Most risk handling options will not completely remove the risk. The remaining risk must be identified in the same terms, format, and degree of detail as was used for the original risk assessment. Once risk handling options are chosen, the remaining risk will carry over into the program risk description.

From the viewpoint of the program decision makers, each risk handling option is an alternative action plan that modifies the acquisition strategy based on its own set of cost, schedule, performance, and risk. The risk handling option analysis results should be structured to allow decision makers to compare these parameters.

Identified risk events are often called “known-unknowns”. In other words, we can identify an adverse event that may occur, but we are uncertain as to its probability and/or the severity of its consequence. Risk analysis helps us to better understand the “known-unknowns”. Other adverse events may occur that were not anticipated. These are called “unknown-unknowns”, meaning that we can neither identify the event, its probability, nor its consequence. Dealing with unknown-unknowns is a challenge for every program. One way to do so is to compare the final program cost and schedule plan, after adjustment for known risk events, to the cost and schedule results of other comparable programs. After making adjustments for differences between the acquisition strategies, the remaining cost and schedule difference can be used as an indicator of the effect of unknown-unknowns. Management reserve is the only way to handle these potential risk since, by definition, there is no way to determine the risk information needed to develop other responses.

It should be clear that integration of risk handling option analysis with all other program planning and controlling activities is essential. On the one hand, if those doing the risk handling option analysis are unable to affect the acquisition strategy, their range of options will be very limited, On the other hand, if the program planners are not fully aware of the risks involved in their strategy options and of the alternatives which might be available to reduce risk, it is unlikely that they will develop the best acquisition strategy.

- Risk Handling Option Integration, Selection, and Implementation

The objectives of this process step are:

- To integrate the analysis of the lower level risk handling options into program level options that are feasible and that provide the best total balance between cost, schedule, performance, and risk for the entire program.

- To produce and implement a final program risk assessment plan that honestly describes the risks facing the program and their risk handling methods.

Integration is necessary to identify the cross-element effects of risk handling options. An option that does not provide the best cost-benefit ratio for a single element may be the best choice when its risk reduction effects on other elements are considered.

All program IPTs should be represented during this process step to ensure that the effects of handling the options and the evaluation of the remaining risk events consider the needs of the entire program.

The risks that remain after choosing risk handling options should be used to update the risk management data base in the MIS. This baseline update will serve as the basis for evaluation of the effectiveness of the assessment process later in the program.

One of the principal products of this step will be the program watch list - a part of the risk management plan. The watch list will contain the top program risk events, their potential effects on the program, the indicators for their occurrence, and the risk handling options put in place to deal with them. Risk handling processes and management reserves should be oriented to maintain visibility of identified risk events ensuring that mitigation actions are effective.

The cumulative effect of the element’s risk events should be integrated to produce a program level assessment of the range and probabilities of cost, schedule, and performance results within the context of the program’s acquisition strategy. The intent is to give program decision makers a well grounded understanding of the uncertainties associated with their program. At the least, program decision makers should be briefed on the principal remaining risk events, their possible effects on the program, and the plans for dealing with them.

Figure 7 - Risk Monitoring/Reporting

The risk handling options chosen by the empowered IPT and implemented in program management plans will form the basis for development of the risk monitoring/reporting system. See Figure 7. Ideally, the risk monitoring system will be an integral part of an overall cost, schedule, performance, and program control system designed to support program management.

The objectives of the risk monitoring/reporting system are to:

- Continuously assess risk events in order to provide current risk information to support program decision makers.

- Ensure that risk stays within acceptable limits.

The risk monitoring system is targeted toward results from the application of risk handling options, monitoring those risk events that remain after application of risk handling options, and identification of unknown risks events yet to be detected. It should include the elements of an effective management control system and be designed to support the decision makers by providing only that information needed for the decision in a format tailored to the needs of the decision maker. It should include an identified standard and baseline, a means to collect data to allow comparison of progress relative to that standard and baseline. The frequency of the collection of data should be consistent with the frequency of the decision supported and the time required to act if action is necessary.

For identified risk events, the control system should be targeted toward specific decisions, such as application of management reserve or activation of a contingency plan. It should be based on metrics that show whether the risk is increasing or decreasing. The type of control system used depends on the type of risk. For technical risks, Technical Performance Measurement (TPM) systems which specify the indicator, performance objectives, performance bands, and action limits are often effective. Cost and schedule variance tracking will usually be an effective means of monitoring. Major technical and program reviews are controls that should include a review of the risks which pertain to the decision under consideration. For example, the Integrated Baseline Review (IBR) is a key activity of the Monitoring and reporting Phase. The purpose of the IBR is to ensure that the baseline captures the entire technical scope of work; is consistent with contract schedule requirements; and has adequate resources assigned. It is normally conducted by Program Manager no later than six months after contract award. The technical staff is heavily involved. The Cost/Schedule Control System Criteria (C/SCSC) Field Command Focal Point and program office financial personnel will provide support to the Program Manager and Technical Staff during this review.

As discussed earlier, risk events not previously identified will appear as the program progresses. You will be alerted to these risk events through cost, schedule, and performance problems that result from factors not considered in earlier risk analyses. These new risk events must be integrated into the overall risk management program.

Risk Re-Assessment

Iterative assessment is critical to program success. It updates the status of known risk events and adds newly identified events to the risk management process as they are discovered. Periodically, the program must formally re-assess risk, using the information gained since the previous effort to define their risk management system. As a minimum, a re-assessment should be done prior to every milestone or whenever there is a change in program managers. Risk must also be re-assessed whenever there is a significant change to the acquisition strategy or its cost, schedule, and performance objectives. Re-assessments require a updates to the risk management MIS. By comparing predicted to actual outcomes, the risk management team can identify strengths and weaknesses in their assessment techniques and evaluate the effectiveness of the risk management process. Without this data base, the program will have to re-learn its lessons every time it goes through a new phase. Once the program has a history, that history should be one on the most effective predictors of future performance, risk, and the degree of confidence that can be placed in risk assessments. All risk management lessons learned should be shared with the acquisition workforce via the acquisition desk book.

Program Risk Management Principles - A Summary. The following principles summarize the major lessons in this teaching note.

- The primary goals of program risk management are to support the development of the acquisition strategy to meet the user's need with the best balance of cost, schedule, performance, and risk, and to reduce the likelihood of failure by identifying risk events and dealing with them explicitly.

- Poor program planning will exacerbate a program's risk management efforts by establishing unrealistic objectives that do not recognize and account for program risk.

- Risk events must be dealt with and defined in terms of the probability of their occurrence and their effects (consequences) on cost, schedule, and performance.

High, low, and moderate risk should also be defined in terms of probability of occurrence and cost, schedule, and performance consequences/impact.

Risk can only be assessed within the context of an acquisition strategy. Change the acquisition strategy and you change the risk.

- Unless the original plan was sub-optimal, risk reduction will almost always involve trading off cost, schedule, and performance.

Risk is defined in terms of Cost, Schedule, and Performance Risk. Under the "Cost as an Independent Variable" (CAIV) concept, as cost-performance tradeoffs (including risk) are made on an iterative basis, aggressive cost goals are established that become more of a constraint, and less of a variable. Therefore, the PM may reduce the costly impact imposed by the law of diminishing returns by trading marginal utility of performance to meet CAIV cost objectives. See figure 8.

Risk can never be fully eliminated or completely transferred.

- The principal purpose of research and development is to reduce the uncertainty, and thereby the risk, associated with acquiring a new system.

The default risk handling option in the absence of a quality risk management process is Assumption of risk.

Quality Management Course (APQMC)
Ground-to-Air Missile System
GTAMS Risk Management Process

This caselet is based on risk management plans collected from a number of actual programs. The circumstances have been modified to provide clear examples of risk management related lessons learned and provide students with an opportunity to evaluate a hypothetical risk management program and make recommendations to improve the process to mitigate a program's risk within an Integrated Product and Process Development (IPPD) / Integrated Project Team (IPT) environment. This caselet is not based upon any specific service missile acquisition program.

SITUATION

You are the new deputy program manger for an ACAT I, single-service, ground-to-air anti-missile system whose past and future schedule is shown in figure 1.

Figure 1

The program manager is also new, having reported aboard only six months ago. He asks you to review the program's risk assessment and risk management approach and to give him a report on your findings.

BACKGROUND

The program began as an informal "Proof of Principal" (POP) program in 1997. The objectives of the POP activities was to identify technological approaches that might be used to counter ground-to-ground ballistic and guided tactical missiles. There was not an originating milestone decision, per se. During the POP activities, the government and three participating contractors were involved in building prototypes and conducting technology demonstrations.

Based on these activities, the program office and the Service decided to issue a detailed RFP, down select to one contractor and go directly into EMD, by-passing the Program Definition and Risk Reduction Phase with a Milestone I/II decision.

The new DoD 5000.2R regulations were issued about eighteen months before the planned milestone review. These regulations have place more emphasis on a formal risk management program than in the past. In response, the program initiated a crash risk management project which produced the current risk assessment and risk management plan.

At the milestone review the decision was made to conduct a forty month Program Definition and Risk Reduction Phase rather than entering immediately into the EMD phase. The principal motivation for this three and a half year delay was service-level budget concerns. The original risk assessment was still considered valid, however, since it was based on technology maturity, and the technical approach was not changed.

The head of the engineering division is the program's principal risk manager. He provided the following history of the development of the program's risk management plan.

RISK MANAGEMENT PREPARATION

Experts were assembled from the program office, government test agencies, user community, and government laboratories, based on their expertise in the following discipline areas:

Hardware: Launcher, Missile,

Propulsion: (considered separately

Communications, and Fire Control since the missile engine was the subject of a separate, fixed price contract)

Software **Program Cost Estimating**

Support: Logistics and Training **Producibility**

There was no contractor participation since the contractor had not been selected when the risk assessment was conducted. Results from contractor risk assessments generated during the POP phase were used, however.

Risk was defined in terms of technology maturity, as follows:

- *High Risk*: Desired level of performance has never been achieved before using this type of technology.
- *Moderate Risk*: Desired level of performance has been achieved using this type of technology, but not in this type of system, or only in a technology demonstration.
- *Low Risk*: Desired level of performance has been achieved using this technology in this type of a system.

The acquisition strategy, to include cost, schedule, and performance objectives and technical approach, was not subject to revision. It had been developed previously by the top program management with feedback from the POP contractors. The objective of the risk assessment was to identify risks and to develop a system to manage those risks.

RISK ASSESSMENT

Risk Identification

Each expert was asked to identify risks within his of her area based on the maturity of the technology involved and the sufficiency of the cost and schedule allocations

Each risk event was described in terms of the performance objective to be achieved and the technical problems which might lead to an inability to reach that performance objective.

Program-level cost risk was assessed separately. Major program level risks to achieving cost objectives, such as sub-contractor management and the adequacy of the Cost-Performance Reporting (CPR) system, were identified by the cost assessment team. The average of these risks was used to determine the program cost risk.

The missile engine had no costs risks due to the fully funded FFP manufacturing contract.

Risk Analysis

Individual and separate cost risks were valued on a scale of 1 (low risk) through 5 (high risk). All evaluation team members were asked to use the standard definition of risk described above.

Risk Integration

Individual risk events were grouped into risk elements and an average risk was determined for each risk element as follows. Each individual risk event was weighted by a factor that represented the importance of that individual event. For example, two equally important individual risk events within a risk element would each receive a weighting of 50%. The total risk for the element was determined by multiplying the weight by the risk value for each risk event, and then adding the resulting products, per the example below:

Individual Risk Value	Individual Risk Weight	Individual Element Risk Product	Average Element Risk Value
4	20%	0.8	
2	20%	0.4	
2	60%	1.2	
			2.4

If there were only one risk, the individual risk weight would be 100%. If a new risk event was identified within a risk element, other risk weights would be re-evaluated to make room for the new event.

Risk elements were ranked within each discipline area. Risk events were not compared across discipline areas due to the differences in valuations between assessment teams. A cut-off line was established for each discipline area to identify top risk events. (see Risk Handling section below)

HANDLING OPTION IDENTIFICATION

Handling Option Identification

The acquisition strategy was considered to be firm. Consequently, the risk assessment team was not allowed to make cost, schedule and performance trade-offs in response to identified risk events. The principal handling options considered were:

- Assignment of specific responsibility for risk element management. Each element manager was expected to have his or her own risk management plan.

- Creation of a risk assessment system whereby successful completion of identified program events resulted in a reduction in assessed risk. The risk management team identified those events which related to element risks, and determined the amount by which risk assessments would be reduced based upon successful completion of the event.

- Creation of a tailored CPR system whereby CPR information related to a risk element was provided to the risk manager with contractor analysis related to variation from plan.

Handling Option Analysis

The risk handling options considered had no significant cost, schedule, or performance trade-offs. There was no evaluation of costs relative to benefits. All options were applied to all risks.

RISK HANDLING

A risk management board, chaired by the deputy program manager and with representation from the principal program and contractor program offices, was created with responsibility for regular review of those risk events above the PM's cut off line. The risk management board presented regular reports to the program manager and Program Executive Officer (PEO) showing the program's progress in reducing the top risks based on successful completion of program events.

Work Group TASKING

Identify problems with the program's current risk management process and recommend improvements. Use the following questions to assist with your task:

Risk Management Function and Objectives. To what degree does the program office understand the management functions and objectives of the risk management process? How effective have they been in supporting program management? What are the principal reasons for their lack of effectiveness? Do they understand and support all of the customers for the risk management products?

Risk Assessment

Risk Event Identification. Was there an effective structure to organize the risk identification effort? If not, what problems were caused? What would be an effective structure? Are you confident that the risk identification was complete and consistent? Was the organization for risk management effective? How could it be improved?

Risk Analysis. Were risk events identified in terms of probability and effect? Were effects identified in terms of cost, schedule, and performance impacts? If not, what problems were caused? How can the process be improved?

Risk Integration. Does the program process for integrating at the risk element level make sense? Is there an effective process for identifying risk at the higher element and program level? Can risks be effectively compared across the program? Are there instances of inconsistent or double-counted risks? In sum, how confident are you that this process provides for a consistent and integrated assessment of program risks? How could it be improved?

Risk Handling Option Assessment

Risk Handling Option Identification. Was the range of risk handling options identified reasonably complete? If not, what limited the identification effort? How could this process be improved?

Risk Handling Option Analysis. Did the program office evaluate risk handling options relative to their cost, benefit (in terms of risk reduction), and feasibility? Did they choose those that would result in the best balance between cost, schedule, performance, and risk? Did the program office identify remaining risk events after application of the best risk handling options? Were the risk assessments updated to reflect the effect of the risk handling options? How effective do you think the chosen risk handling options will be in reducing and handling program risk? How could the process be improved?

Risk and Risk Handling Option Integration. Did the program office integrate the element risk handling options to develop the set of options best for the program? Did they determine the remaining risk at the program level? How could this process be improved?

Risk Handling System Development. Did the program office develop a complete and effective system to track and handle risks? Was the process tied to key program and risk management decisions? If not, what else could they have done? How could they have improved the process

Risk Management Preparations. In light of the problems discussed so far, did the program effectively prepare for risk management? What did they do wrong or fail to do? How did these problems affect the rest of the process? How can they improve in this regard.